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CORRELATION OF HEAD CIRCUMFERENCE WITH BODY MASS INDEX IN A GROUP OF ELDERLY SRI LANKAN POPULATION

Abstract

Introduction: Accurate estimation of the body mass index (BMI) is important in assessing nutritional status, risk of myriad of medical conditions including hypertension, coronary heart disease, adult-onset diabetes mellitus and dementia. However, emergency settings and immobility make it difficult to obtain personal stature and weight using standard methods. Thus, the need for an alternate method of BMI prediction arises.

Objective: Goal of this study was to propose population, age and gender specific regression formula for BMI estimation using HC for an elderly Sri Lankan population.

Material & methods: Personal stature, weight and HC was recorded in a total of 156 cadavers (age: 55 – 89 years);(male: n=74; female: n=82).

Results: The HC (cm) (male: 54.09 ± 3.28; female: 52.88 ± 2.83) was significantly different ($P< 0.01$) between the genders. There was no statistically significant difference between mean BMI (Kg/m2) of male (20.32 ± 4.08) and female (20.93 ± 2.20). Correlation coefficient between HC and BMI was 0.09 in males and 0.04 in females indicating a weak positive linear relationship between the two parameters. Linear regression formulae for the prediction of BMI using HC were derived as follows: male: 14.04 + 0.15(HC); female: 20.03 + 0.02(HC).

Discussion: BMI prediction formulae that require a measuring tape as the only tool to record the HC provide a simple, cost effective and objective method for patients who are unable to stand or weighed. Accurate prediction of BMI will in turn reduce potential errors in pharmacological interventions that may occur when it is estimated only by visual observation in emergency settings. Complementary studies are necessary to evaluate the applicability of these equations in other age groups too.

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INTRODUCTION

Body mass index (BMI), which is defined as body weight divided by height squared (kg/m2), is the most commonly used index in assessing nutritional status of an individual. A large body of evidence shows that the rate of obesity is on the rise like that of an epidemic, in which the global population is becoming alarmingly obese at an exceedingly rapid rate. Obesity causes and exacerbates a myriad of medical conditions including hypertension, coronary heart disease, adult onset diabetes mellitus, poor cognitive function and dementia. Further, it has come to the forefront as a risk factor for Alzheimer's disease (1, 2). It was further shown to be linked with atrophy in the frontal, temporal, anterior cingulated gyrus, hippocampal and thalamus in addition to detectable brain volume deficits in elderly subjects (3).

There are many instances where precise personal stature and body weight of a patient is quite challenging to obtain using standard direct methods. For example, patients with mobility impairment due to neuromuscular diseases or joint deformities who are bedbound or in wheelchairs or in emergency settings when patients are unable to stand on a scale to be measured or weighed accurately or clearly state their most recent height or weight due to altered mental status (4).

Thus, a surrogate measure of BMI is needed, either for acute care management or on long term basis depending on the situation. Consequently, various studies have proposed obtaining personal height and weight through prediction formulas based on various anthropometric variables such as arm-span, knee height, and measures of arm, calf circumferences, subscapular skinfolds, abdominal circumference and cranial dimensions in different populations (4-12). Features that can be expressed as actual measurements, like head circumference, provide more objective assessment of the crania (6). It is stated that the racial characters are most prominently observed in the skull (9). Therefore, HC is an important character for determining racial differences. Measurement of HC is a routine part of a physical examination of a child and is of great importance in detecting abnormal patterns of growth. At birth HC of an individual has reached 62% of adult size while height is only 28% of the adult stature (13).

Evidence supports that HC positively correlates with height and weight of an individual (9, 11, 12, 14-16). As the cranial dimensions are influenced by the race, sex and age of an individual, the need for race, age and sex specific predictive formulae is also proved beyond doubt (9). Moreover, it has been shown that present day average HC is larger than it

was fifty years ago (17). It is important that predictive formulas are valid for a particular population in which they will be used so that the equations cover the characteristics of that population.

Despite its' significance and potential practical utility, little is known concerning the relationship between HC and body size among elderly Sri Lankans. Hence, the goal of this study was to elucidate the association between HC and BMI and to propose population and gender specific regression models for BMI estimation using the HC.

MATERIAL AND METHOD

This study was conducted on total of 156 cadavers donated to the Faculty of Medicine, University of Ruhuna, Sri Lanka. The subjects who are apparently healthy and without any craniofacial, neurological, or vertebral column deformities were included in the study. The age of the subjects ranged from 55 - 89 years.

The personal stature was recorded as the straight distance between vertex of the skull and the heel of the foot. Head circumference was recorded as the maximum circumference of the head measured from just above the glabella to the area near the top of the occipital bone (opisthocranion) (9). Both measurements were taken using a flexible steel measuring tape capable of measuring to the nearest 0.1 cm. The body weight was recorded to the nearest 0.1 kg using a hanging balancer (Avery). The above measurements were recorded at a fixed time between 14.00 – 16.30 hours to eliminate discrepancies due to diurnal variation. All the measurements were repeated thrice and the mean was taken for further analysis. Furthermore, the measurements were recorded by the same person to minimize the errors in methodology.

Results were expressed as mean ± SD and analyzed using the Statistical Package for Social Sciences (SPSS), 15th version. A comparison of the mean values between the genders was performed using the t-test. P value < 0.01 was considered statistically significant. The strength of association between the HC and BMI was measured by the Pearson's correlation coefficient. Equations for BMI estimation were obtained by linear regression analysis.

RESULTS

The mean ages of the study subjects (male: 75.49 ± 7.69; female: 74.66 ± 5.09) were not significantly different between the genders (Table I). Gender differences with respect to the HC, stature and weight was found to be significantly larger in males compared to females

(P<0.01). The mean BMI was larger in females compared to males although gender difference was not statistically significant (P>0.05) (Table I, Figures 1A & 1B).

**Table I. Characteristics of the study subjects; *** P < 0.01

Parameter	Female	Male	Both
Total number	74	82	156
Age range (years)	68 – 83	55 – 89	55 - 89
Mean age (years)	74.66 ± 5.09	75.49 ± 7.69	75.10 ± 6.57
Body height range (cm)	165.70-131.00	180.50-145.00	180.50-131.00
Mean body height (cm)	151.04 ± 9.59 *	162.08 ± 9.02	156.84 ±10.79
Body weight range (Kg)	30.00 – 57.00	34.00 – 93.00	30.00 – 93.00
Mean body weight (Kg)	47.91 ± 7.26 *	53.78 ± 14.14	50.99 ± 11.75
HC range (cm)	58.50 – 50.00	60.00 – 43.20	60.00 – 43.20
Mean HC (cm)	52.88 ± 2.83 *	54.09 ± 3.28	53.51 ± 3.13
BMI range (Kg/m2)	16.85 – 25.64	12.86 – 31.04	12.86 – 31.04
Mean BMI (Kg/m2)	20.93 ± 2.20	20.32 ± 4.08	20.61 ± 3.33

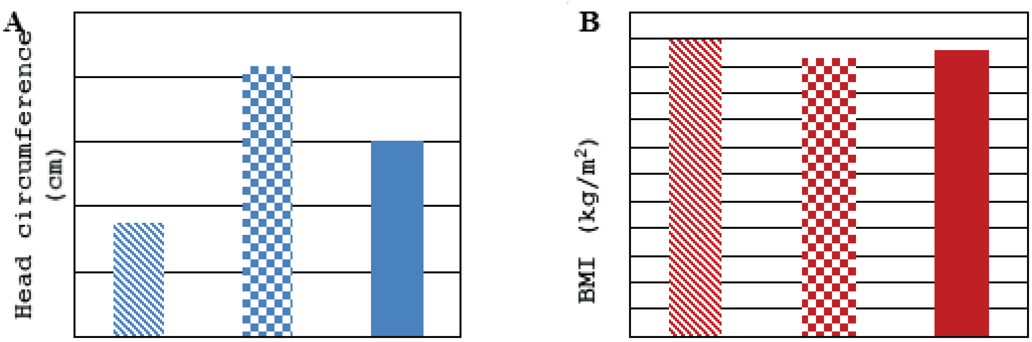

Fig. 1. Gender differences in (A) head circumference (HC) & (B) body mass index (BMI)

A linear regression analysis was performed for estimation of BMI using the HC as an independent variable. Pearson correlation coefficient was used to examine the relationship between HC and BMI according to the gender. Correlation coefficient between HC and BMI was found to be 0.09 in males and 0.02 in females.

Scatter plots and linear regression lines demonstrating the relationship between BMI and HC are illustrated in Figure 2. Linear regression formulae for the prediction of BMI using HC were derived as follows: Female: BMI = 20.03 + 0.02(HC); Male: BMI = 14.04 + 0.15(HC); Both male & female (combined): BMI = 18.11 + 0.05(HC).

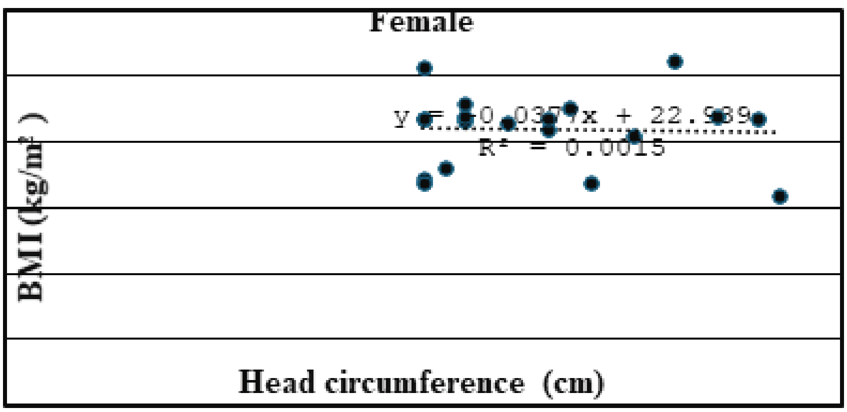

Fig. 2a. Scatter plot and regression line demonstrating the relationship between head circumference (cm) and body mass index (Kg/m2) in females

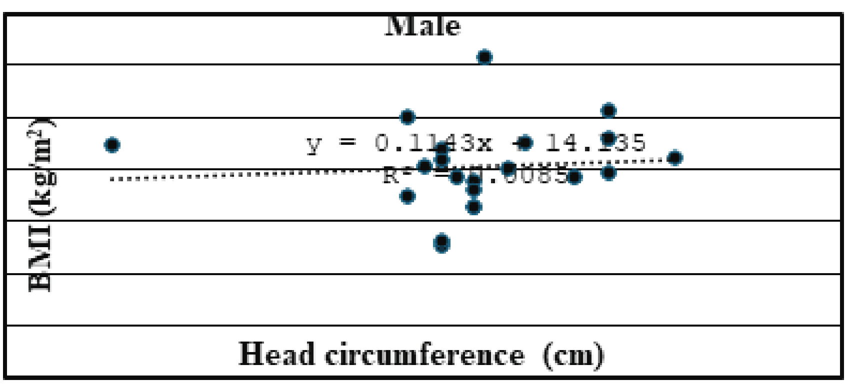

Fig. 2b. Scatter plot and regression line demonstrating the relationship between head circumference (cm) and body mass index (Kg/m2) in males

DISCUSSION

The present study provides an insight pertaining to the HC and its correlation with the body size in an elderly Sri Lankan population. Clinically, BMI is extensively used as a simple index of body adiposity and also as a surrogate measure of obesity among adults, adolescents and children as the current standards for overweight and obesity are based on BMI (18).

The significance of estimating BMI is multifold. Firstly, BMI was shown to change over the life cycle of an individual: from birth BMI increases up to 1 year of age followed by a downfall by 6 years and again increases up to 18 years of age. The downfall of BMI in early childhood is attributed to adiposity rebound which in-turn is shown to predict adult obesity and chronic energy deficit status. Therefore, the significance of monitoring and recording of BMI in growth-monitoring programmes cannot be underestimated (19).

Secondly, BMI serves as a useful tool in the assessment of nutritional status and to monitor the effectiveness of nutritional interventions. On the other end of the BMI spectrum is malnutrition, which significantly affects both physical functioning and cognition, resulting in increased morbidity and mortality. BMI is considered as an important predictor of mortality in the critically ill patient (20). Accurate assessment of the BMI is considered to be the first step in initiating correct preventive and treatment programs. Therefore, BMI plays a vital role not only as a screening tool for the early diagnosis and consequent management but also for preventing the risk for obesity or malnutrition by facilitating early adjustment of nutritional needs which in-turn will result in improved clinical outcomes and reduced health care costs.

Thirdly, BMI influences the pharmacokinetics and pharmacodynamics of many common drugs. Some of the drugs that need dose adjustment in obese patients include low molecular weight heparins, aminoglycoside antibiotics, some anesthetics and chemotherapeutics. However, precise drug dosing guidelines are lacking for obese patients leading to arbitrary dose determinations which in-turn may cause therapeutic failure or drug toxicity (21). Similarly, due to adverse side effects of certain drugs, higher doses cannot be prescribed for obese individuals while at the same time low doses can result in sub-therapeutic exposure leading to treatment failure. Taking all these factors into consideration, it has been pointed out the significance of considering BMI as a guide and to re-consider the drug dosing in obese individuals (21, 22).

The assessment of height and weight is an essential requirement for calculating BMI according to the standard procedure. Under certain circumstances such as, frail elderly with co-morbidities, disabilities, immobility and cognitive impairment, when it is not possible to obtain the individual's height and weight through standard, direct procedures, the alternative methods through regression formulae are used to estimate BMI. Such methods to accurately predict BMI improve medical and pharmacological interventions which in-turn may minimize dosing errors that may occur when body size is estimated only by visual.

observation in emergency situations (3). It was interesting to note that evaluation of results of several studies that assessed the predicted BMI using regression formulae and actual BMI have demonstrated no statistically significant differences (23, 24).

Gender differences with regard to HC, height and weight of the current study population were statistically significant. However, when height and weight values are converted to BMI, gender difference was statistically insignificant. Correlation coefficients between the HC and personal stature (male: 0.62; female: 0.86) and body weight (males: 0.75; female: 0.37) among Sri Lankan adults has shown a strong positive relationship (10, 12). Hence, as to why there was a weak correlation between the HC and BMI remains to be explained. It is also noteworthy that, in comparison to other cranial dimensions, HC was shown to be the best stature predictor in Sri Lankan and Indian populations (9, 10).

Most of the predictive equations have been shown to be de¬pendent on factors pertaining to age, gender and ethnicity. Moreover, BMI prediction equations that are formulated for Eu¬ropeans, Caucasians or sub-Saharan Africans may not be valid for south-east Asians as they differ signi¬ficantly in anthropometric and morphologic cha¬racteristics from the others (25). In view of these limitations, the current study provides practically applicable gender and age specific BMI prediction formulae using HC for Sri Lankan population. BMI prediction equations that use a measuring tape as the only tool is a simple, accurate, non invasive, cost effective and reproducible alternative for the direct method. Further, since these predictive models include only one variable which minimize the handling of a bedbound patient, thus enhancing its applicability. These formulae are valid for the age group 55 – 89 years. It is widely accepted that HC varies with the age of an individual. Therefore, complementary studies are needed to evaluate the applicability of these equations in other age groups.

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